GEOS-5 Status (AGCM)

First public CVS "tag" released in April. Releasing updates fairly regularly ~1/mo

Current tag "Cerebus" running upto _ degree resolution. Production at 1x1.25.

Significant physics update planned for this month.

First complete coupled AGCM/GSI-DAS scheduled for release in July

GEOS-4 vs GEOS-5

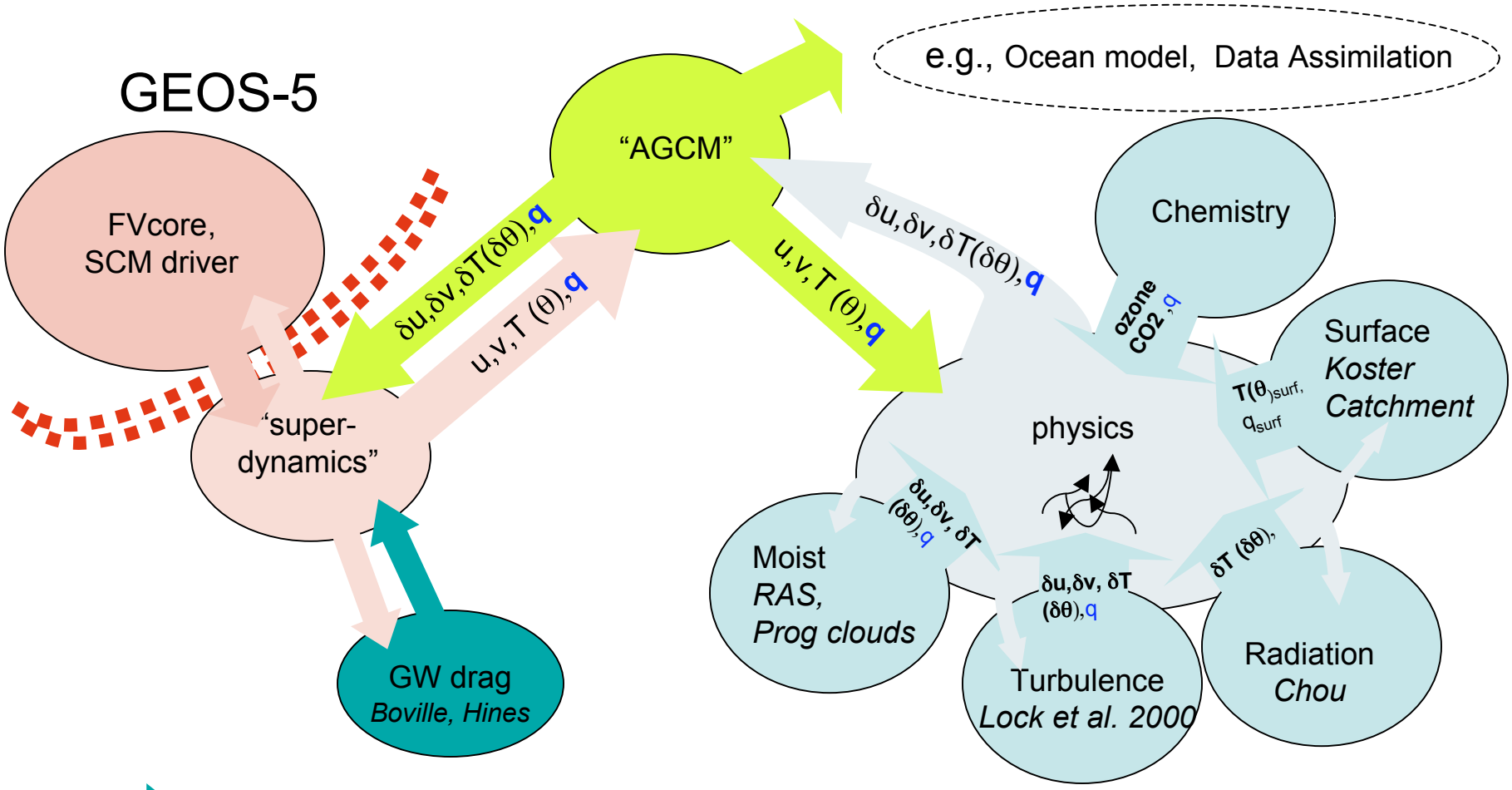
	GEOS-4	GEOS-5
Dynamical Core	Lin-Rood FV	Lin-Rood FV
Turbulence:	Holtslag-Boville non-local	Lock et al 2000 w/ mods
Moist Physics	Diagnostic Clouds + Zhang-MacFarlane/ Hack convection	Prognostic clouds+ RAS convection
Radiation	NCAR	M. D. Chou
GWD **	Boville, **	Boville, **
Land Surface	Community Land Model	Koster et al. catchment based
"Plumbing"/ infrastructure	N/A	ESMF

Optionally,* *different topographic forcing files.

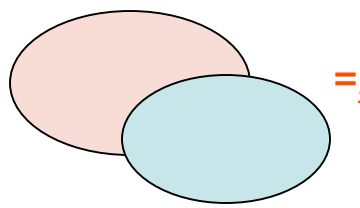
Why GEOS-5?

GEOS-4 physics were esentially CCM3 physics. Most components needed updating. Favored in-house development to streamline interactions across a variety of projected applications; e.g. data assimilation, climate studies, seasonal forecasting.

Wanted to develop using new ESMF structure intended to facilitate “inter-operability” of various systems



Plumbing uses ***ESMF***.



=***ESMF*** "gridded components"

SCM version of GEOS-5 exists

SCM and full AGCM structurally identical – distinction occurs only at run-time and is based on initialization files, compiler switch.

GEOS-5 SPECIFIC COMMENTS

- In GEOS-5 we chose to use a fine-grain component design: ESMF components at the parameterization level, which must be fairly light-weight.

- We use a hierarchical topology using composite components, and so we are concerned with the relations between parents and children

GEOS-5 SPECIFIC COMMENTS

- Gridded components may define their own grid or work on a given grid, usually they simply inherit the parent's grid.
- All control is by an inherited Configuration, which is treated like the environment of UNIX processes
- Three major extensions of ESMF concepts:
  - GEOS Generic provides default Initialize and Finalize methods and a Generic SetServices to do ESMF "boilerplate"
  - GEOS Generic defines an Internal State.
  - In GEOS Generic, SetServices is extended to provide *data* and *connectivity* services

GEOS-5 SPECIFIC COMMENTS

- Data services allow you to describe your import, export and internal states, giving each variable attributes like names, units, dimensionality, usage attributes, grid associations, etc.

- Import states are read only to you. Export states are read only to others. This allows the passing of pointers rather than copies and so lightens the coupling.

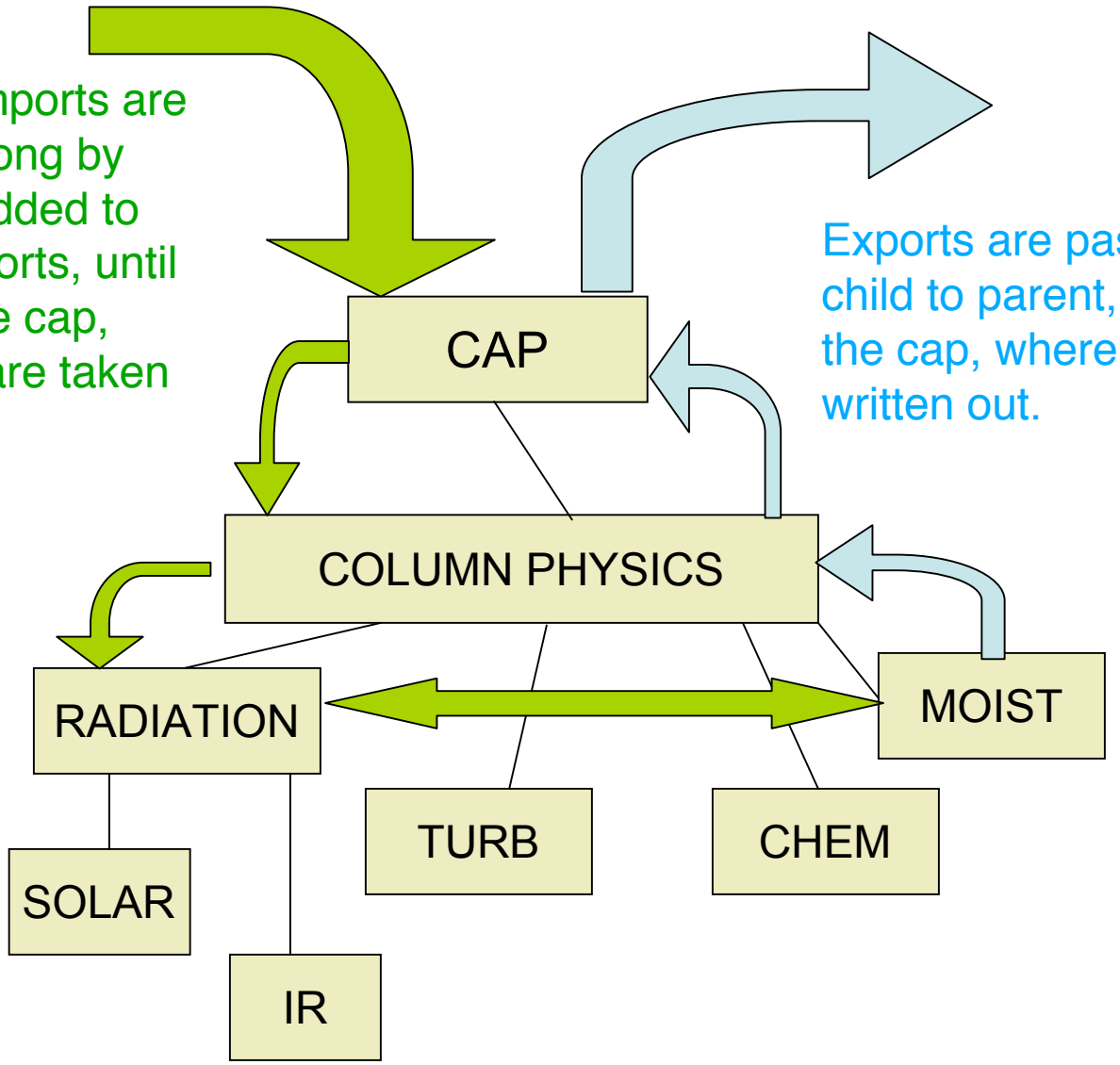
- GEOS Generic creates, allocates and initializes, as appropriate, variables in all three states, putting them in ESMF classes (Arrays, Fields, Bundles, States) that are used by the infrastructure.

- Import and Internal states are optionally checkpointed and restarted by Generic Initialize and Generic Finalize.

GEOS-5 SPECIFIC COMMENTS

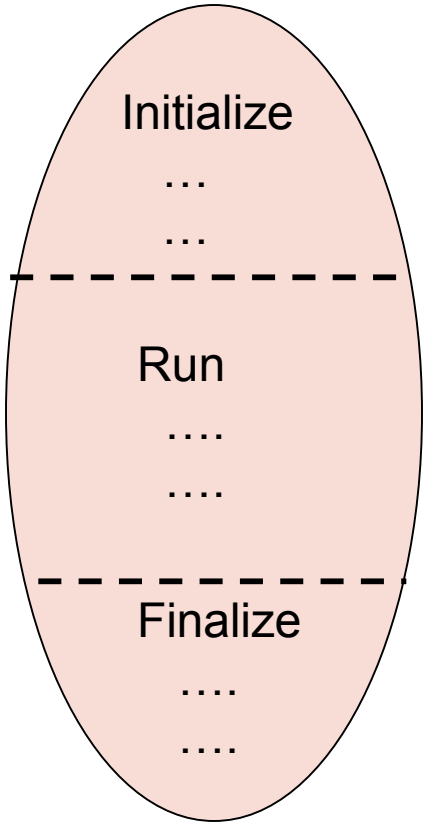
- The connectivity services include:
  - declaration of children
  - control of how child's and self's imports and exports are connected to each other and to the outside
  - declaration of special "friendly" relationships between components that must operate on large or open-ended sets of state variables, etc.
  - Restrictions apply.

Children's imports are satisfied among by siblings or added to parent's imports, until the reach the cap, where they are taken from restart.



Exports are passed up from child to parent, until they reach the cap, where they can be written out.

GEOS generic, ESMF “child”-type Gridded Component (GC)



Initialize:
-Declares/specifies needed “imports” e.g.cloud fraction in radiation GC.
-Declares exports that *can* be provided e.g. cloud fraction in moist GC
-Specifies internal state if needed (*vars, grids etc.*)
-Reads internals and imports from restarts if necessary
-Organizes other kinds of configuration issues (e,g, parameter files)

Run:
-Allocates/fills arrays from internal, import, and export states that will actually be used in calculations.
-Reads in parameters
-Often calls “ordinary” f77 or f90 subroutines that do the computational work

Finalize:
-Writes checkpoint files for internal and import states if necessary

Parent GC decides which children’s exports fill others’ imports, or whether these must brought in from outside, e.g., u and v for turbulence in physics must come from dynamics GC.

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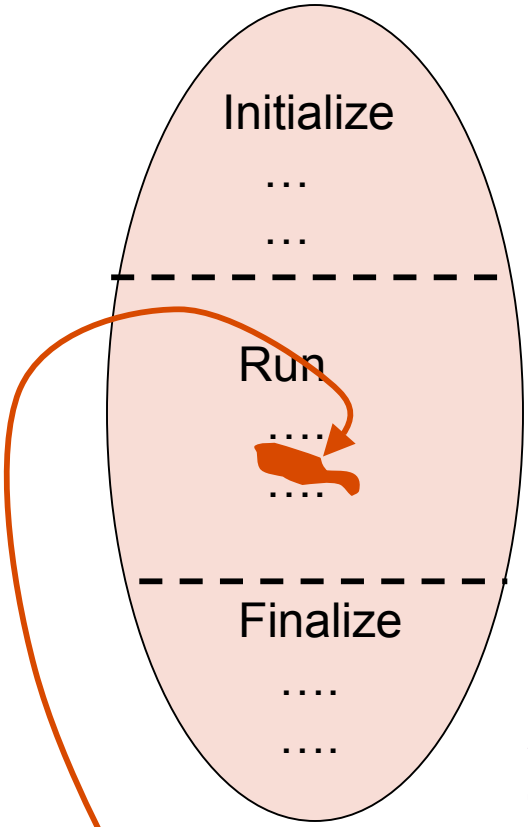

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Recognizable fortran code usually found here

Moist Physics for GEOS-5

Moist physics contains RAS convection and large-scale cloud condensate Scheme. Two phases (liquid and ice) of condensate + two "families": A) convective source, B) statistical source = 4 prognostic condensates

Inputs to moist physics T,u,v,q *(recently updated in dynamical core)*

RAS

inputs T,q,u,v
outputs convective condensate profiles, updated T,q,u,v

Prognostic Cloud scheme

inputs T,q,u,v, convective condensate profiles
outputs updated T,q,u,v, condensates, cloud fractions, rain rates

(post-processed for radiation)

f_{tot}, q_{vap},q_{ice},q_{liq},R_{ice},R_{liq},R_{prec}

RAS with enhanced microphysics, loosely following Sud and Walker (1999)

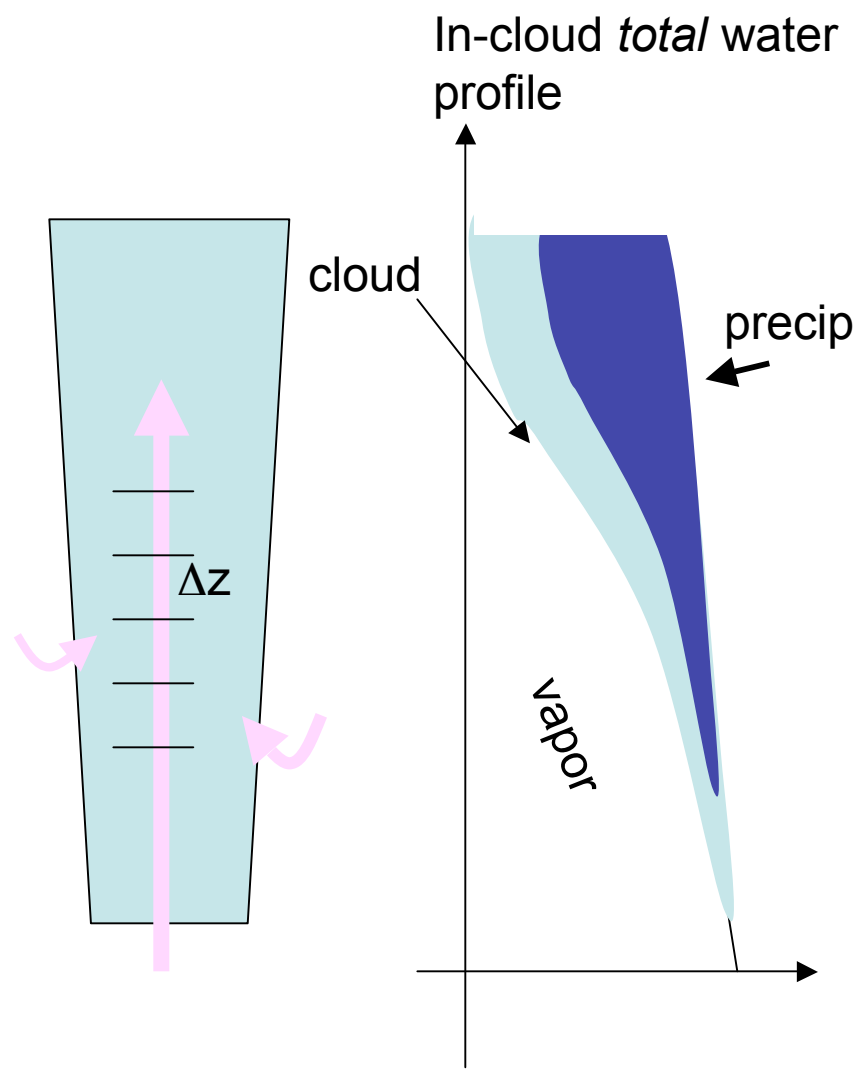
- *Each call invokes "spectrum" of plumes*
- *Choose cloud-base, cloud-top.*
- *Find necessary plume entrainment*
- *Calculate mass fluxes*

Now estimate a steady-state updraft velocity from Cloud and environmental profiles.

This provides time scale - $\Delta z/w$ for auto-conversion of cloud to precip

Currently in-plume cloud condensate not included in radiation calculation, but could be with little difficulty

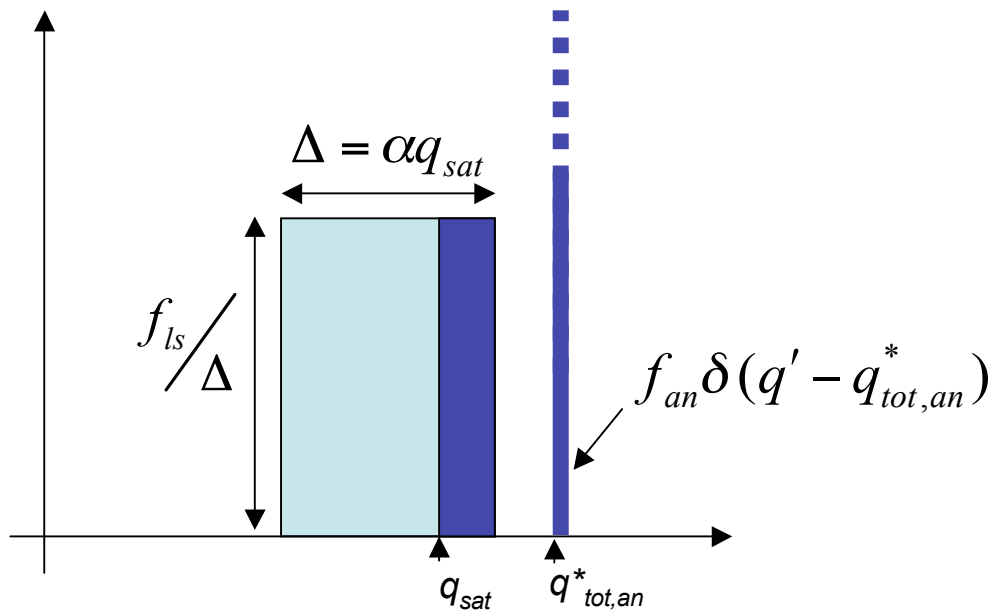
Cloud detrainment levels can be sequential or random. Cloud base can be fixed or variable, e.g. LCL, PBL top.



Prognostic cloud scheme

Two phases (liquid and ice) of condensate

Two "families": A) convective source, B) RH-based, large-scale source.
Equivalent to bi-modal PDF of total water:



Prognostic cloud scheme

SOURCES:

Total new LS condensate at each step determined from a single ramped RH function

Convective mass and condensate fluxes

New ice phase condensate added, according to same simple linear ramp in T, for both LS and conv source.

SINKS:

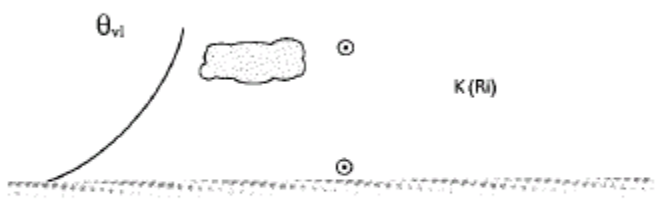
Autoconversion with Sundquist-type T-dependent expression for loss rate

Settling/Sedimentation of ice-phase condensate with terminal velocities from Lawrence and Crutzen (1998)

Scavenging/Accretion by precipitation

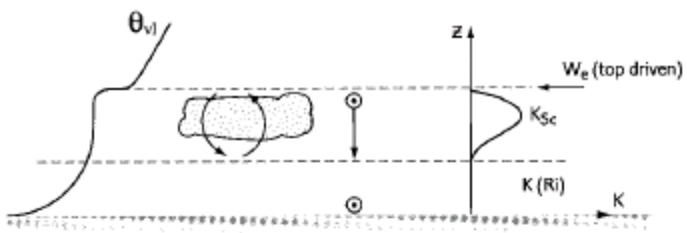
All precipitation is disposed of in prognostic cloud scheme. Three separate "showers" considered: 1) updraft-core, 2) anvil stratiform and 3) large-scale. Same but separately tunable re-evaporation formulation used for all 3.

Lock et al. 2000 Turbulence scheme. Invoked in unstable or cloud-topped PBLs.

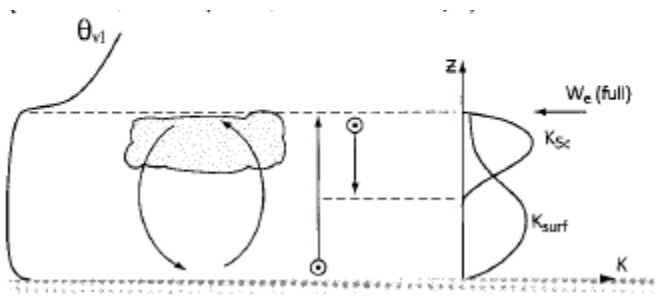


Stable situations w/ no or weakly-cooling PBL cloud still use Louis et al. 1982 1st order scheme

Non-locally determined K-profiles via test parcels



Strongly cooling PBL cloud.



Unstable surface layer (shown here added to cloud top -driven K_{zz}.)

GEOS-5 extension: unstable surface parcel calculation includes moist heating and entrainment.

Other extensions to turbulence/surface exchange parameterizations.

Beljaars orographic form drag parameterization.

Viscous sublayer over oceans.

Redelsperger 2000 convective gustiness (optional).

AeroChem

(da Silva, Nielsen, Colarco, Pawson)

ESMF GC running in GEOS-4 being implemented in GEOS-5 (same code). Completion by Summer 2005.

GSFC GOCART

GSFC STRATCHEM

parameterized O3 CO

GMI Combo Chem to be integrated into AeroChem

Constituents transported on-line within GCM subject to model advection, convection, diffusion

2 modes

direct simulation

"replay mode" (requires only u,v,T,q fields. Physics replays itself)

GEOS5 CTM also planned

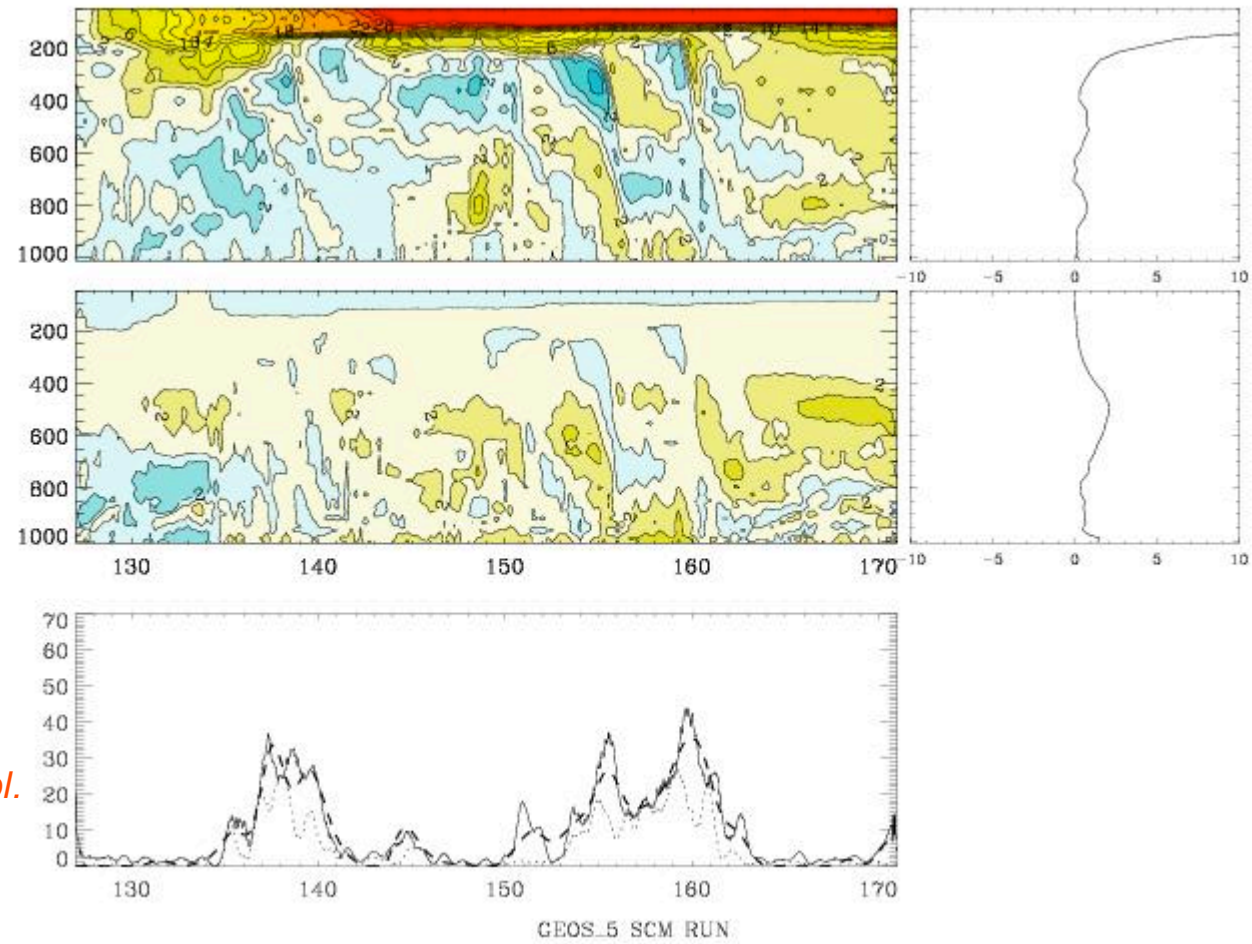
GEOS-5 SCM

SCSMEX (North), 5/7/1998 – 6/20/1998, Prognostic-A
full advective *T, q* tendencies
obs. SST, instead of analyzed sfc. fluxes

T-error (K)

q-error (g/kg)

Precip. (mm/d)
time smoothing appl.

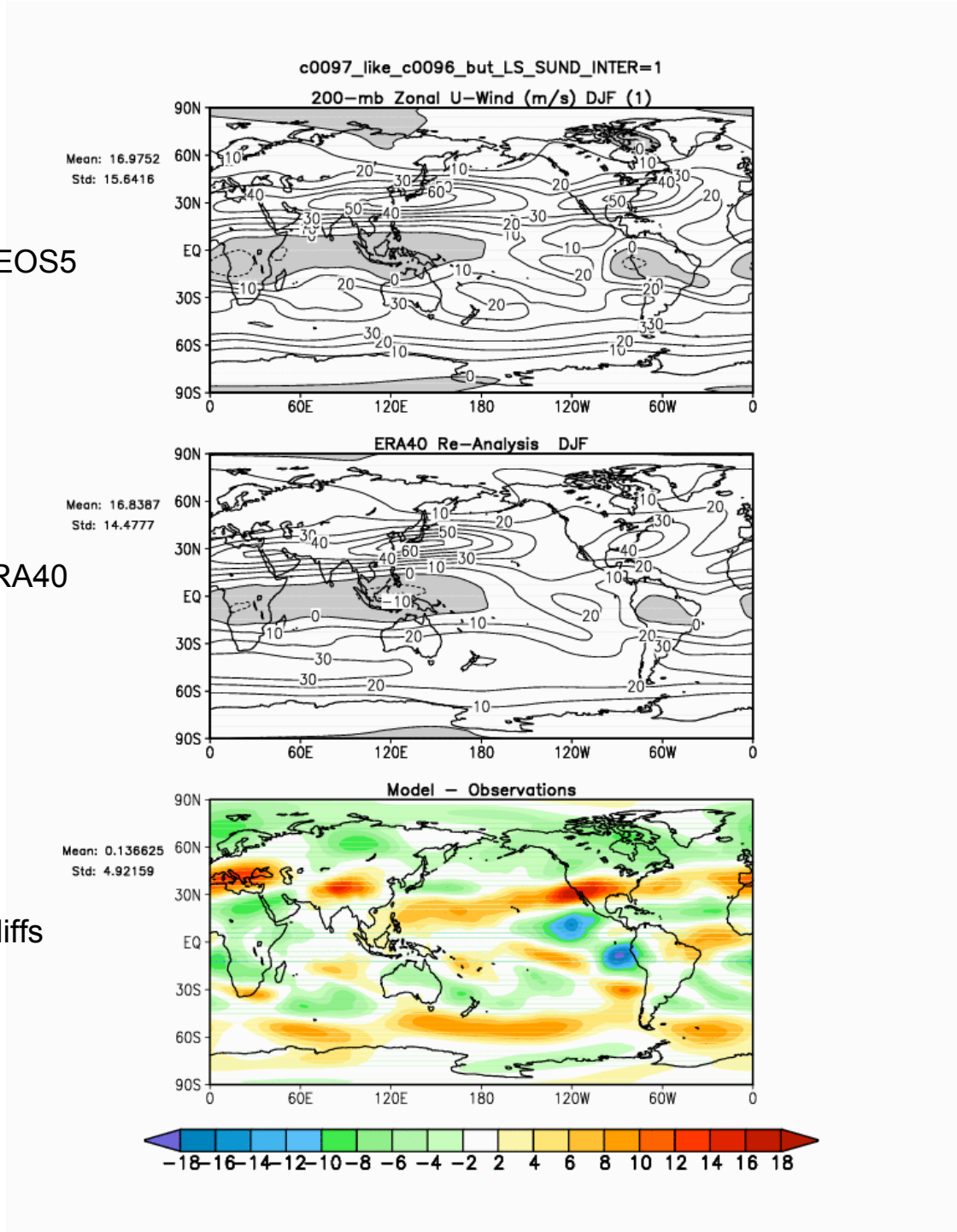


200 hPa
Zonal wind
DJF

GEOS5

ERA40

diffs



Zonally averaged *T* and *q* for DJF vs ERA40

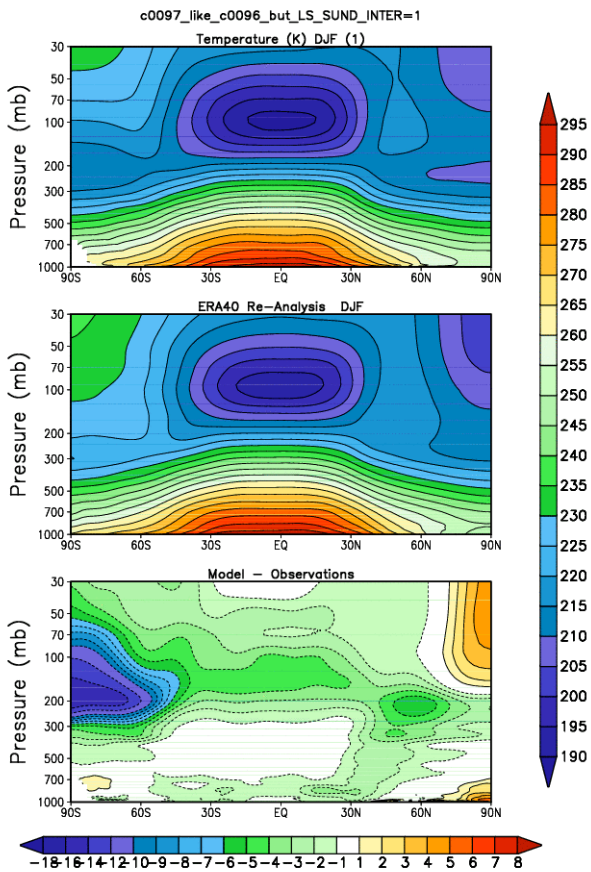
T

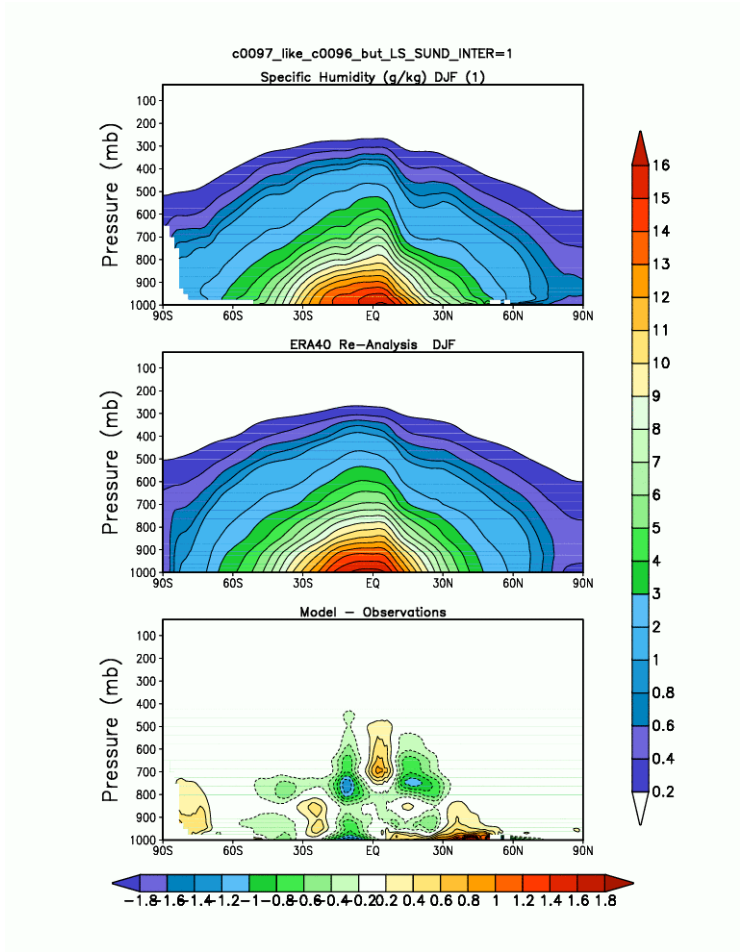
q

GEOS5

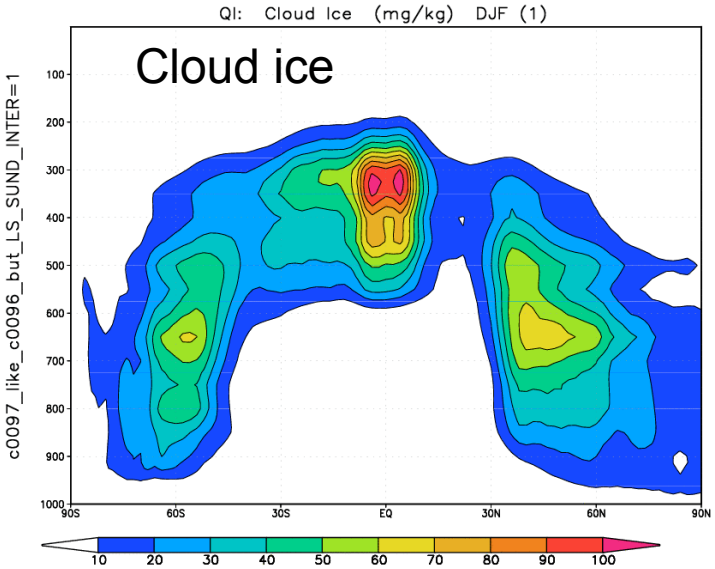
ERA40

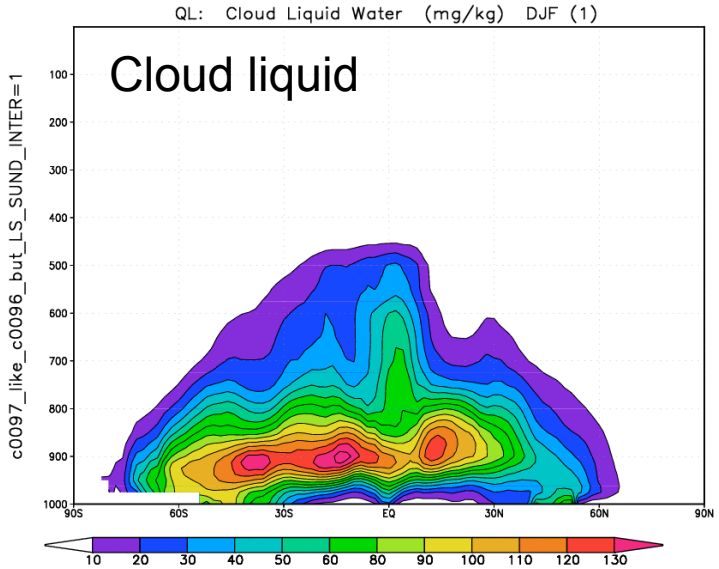
diffs



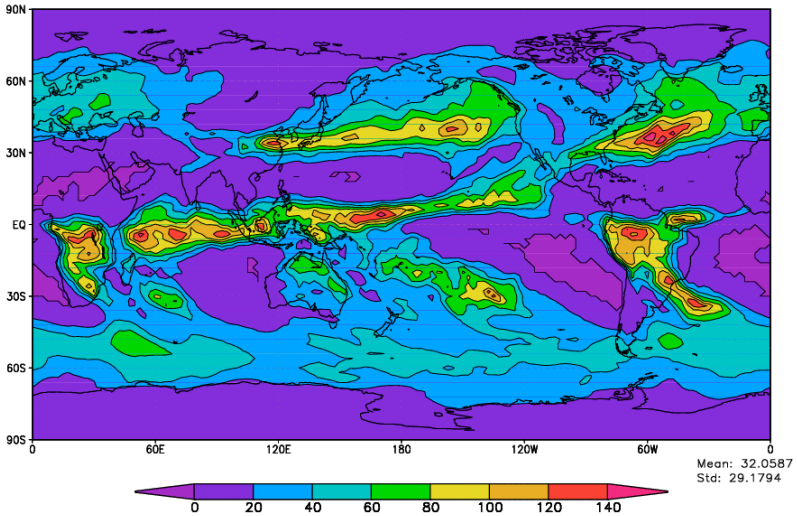


DJF means

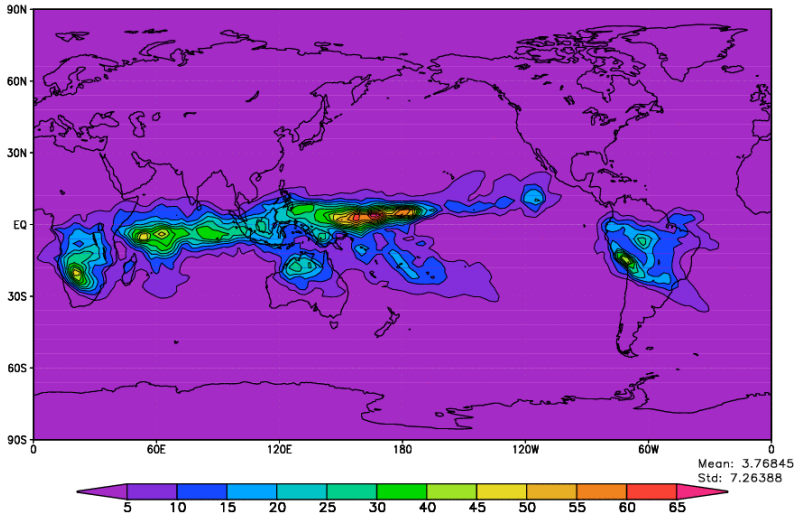




500 hPa Cloud ice



200 hPa Cloud ice



Summary

ESMF-based GEOS-5 AGCM released in April 2005. Development continues.

GEOS-5 physics include 2 phase prognostic cloud scheme w/ relaxed Arakawa-Schubert convection scheme, Lock et al. PBL scheme, catchment based land model (Koster).

AGCM coupled to new GSI-DAS in July

Arlindo Da Silva developing ESMF chemistry aerosol component

AGCM coupled to ocean model in near future

Complete single column version of GEOS-5 exists. Identical to full model